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Physical Activity Intervention for Loneliness (PAIL) in community-dwelling older adults: a randomised feasibility study

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17 **Background:** Low quality social relationships in older adults are strongly associated with feelings
18 of loneliness. Physical activity interventions could reduce loneliness and improve psychological
19 well-being, among other health benefits. The aim of this study was to examine the feasibility of a
20 Physical Activity Intervention for Loneliness (PAIL) in community-dwelling older adults at risk of
21 loneliness.

22 **Methods:** The PAIL feasibility study was a 12-week randomized controlled feasibility trial (RCT)
23 conducted in Birmingham, United Kingdom, from February 2018 to August 2018 and ran in two
24 waves of data collection. Eligible participants were community-dwelling adults aged 60 years and
25 older, sedentary (less than 20 min of moderate-to-vigorous PA (MVPA) a week), and at risk of
26 loneliness. The intervention included: once weekly group walk and health education workshop up to
27 90 minutes per session in total, with a wait-listed (WL) control group. The primary feasibility
28 outcomes were to estimate recruitment, retention rates and adherence to the intervention. Secondary
29 outcome measures (not blinded assessment) were body mass index, blood pressure, physical activity,
30 and psychosocial variables. Process and outcome evaluations were conducted using focus groups
31 interviews. The recruitment and retention progression criteria for the definitive large-scale RCT was
32 set *a-priory*.

33 **Results:** Forty-eight participants were recruited over 4 months with a recruitment rate of 25%
34 (48/195); 52% (25/48) met the inclusion criteria and 100% (25/25) were randomised into the
35 intervention (N=12) and WL control groups (N=13). Participants were 25 older adults (mean (SD)
36 68.5(8.05) years), 14 (56%) female, and 18 (72%) white. At 12 weeks, 10/12 (83.3%) intervention
37 and 10/13 (76.9%) control participants completed the final assessments. The average attendance rate
38 was 58.3% for the intervention group (range 33.0%-75.0%) and 42.3% (range 23.1%–69.2%) among
39 controls. The *a priori* recruitment and retention criteria for progression were not met. No serious
40 adverse events occurred. The focus group results identified three themes which showed overall
41 positive experiences of participation in PAIL in terms of: 1) study design and intervention; 2) walking
42 sessions; and 3) health education workshops.

43 **Conclusions:** The findings suggest that community-dwelling older adults at risk of loneliness found
44 the intervention and measures acceptable and could safely participate. However, a more extensive
45 and robust strategy would be needed to support adequate recruitment of lonely older adults and
46 adherence into a definitive RCT.

47

48 **Trial registration:** Clinicaltrials.gov Identifier: NCT03458793.

49 **Keywords:** Feasibility study, Physical activity, Loneliness, Older adults, Randomised Controlled
50 Trial.

51

52

53 **Background**

54 Maintenance of social connectedness throughout the lifespan is an important aspect of successful
55 ageing [1]. The disruption of established social patterns or poor quality of social relationships is
56 strongly associated with loneliness especially in older adults [2]. Defined as a discrepancy between a
57 person's desired and actual social relationships [3], loneliness and a lack of social relations are
58 considered to be high risk factors for morbidity and mortality, and the negative impact of loneliness
59 can be as harmful as smoking fifteen cigarettes a day [4]. Due to deteriorating health condition of
60 older adults and less abilities to engage in social connections, the early prevention of loneliness in
61 community programmes seems prudent.

62
63 Due to deteriorating health conditions associated with ageing, older adults are highly predisposed to
64 declines in cognitive and physical function [5]. However, regular exercise in older adults at the
65 recommended minimum of 150 min of moderate PA per week performed in any length of bouts [6]
66 can contribute to the maintenance of physical health. Additional benefits are associated with muscle
67 strengthening and balance exercises performed in 10 min bouts for the risk of falls prevention [7].
68 Moreover, active older adults retain cognitive function at a high level throughout their older years,
69 which is a very important aspect of social life and wellbeing [8, 9]. It is a health behaviour that can
70 increase peripheral social networking and the acquisition of new social contacts due to engagement
71 in a variety of physical and leisure activities by older adults outside the home. In turn, this can replace
72 or compensate lost social connections for older adults with feelings of loneliness, and turn these
73 feelings into meaningful social connections based on the social compensation model [10]. PA
74 improves psychological and emotional wellbeing leading to direct health benefits based on the so-
75 called "feel-good effect" of exercise identified in the literature [11], which is associated with increases
76 in serotonin, monoamine and neurotrophin production and reductions in the stress hormone cortisol
77 [12].

78

Mechanisms of action of PA interventions are suggested to relate to loneliness reduction models, stress reduction, and increased social support during activities. The social compensation model [13] suggests that PA can work via compensation for lost meaningful social connections due to increased peripheral social networking during friendly conversations between participants [14]. The hypothesis of the broaden-and-build theory of positive emotions [15] posits that enjoyable forms of PA generate happiness and bring positive emotions, which in turn could be associated with loneliness reduction [16]. Based on the stress/social support model [17], social networks promote well-being that is associated with loneliness reduction in older adults. Finally, the tripartite model of group identification has been shown to be effective in group-based PA settings among specific population groups, such as lonely seniors, due to a sense of social identification [18, 19]. This model considers three aspects, such as cognitive (social categorisation, i.e., the degree by which an individual categorises him/herself as similar to other group members), affective (i.e., the degree to which an individual feels affectively attracted to the other group members), and behavioural (interdependence, i.e., the degree to which an individual evaluates his/her group as important for teaching objectives) [18, 19]. Through shared interests and goals during engagement in physical activities it boosts social activity and leads to group identification through the feeling of social attraction to other group members.

A previous review found that few PA interventions for loneliness reduction have been conducted in community settings [20]. This is also consistent with previous systematic reviews and meta-analyses [2, 18, 21, 22]. Results of meta-analysis performed for social functioning (as a sub-domain of health-related quality of life) in this review showed, that specific aspects of PA interventions can successfully influence social health [20] with the strongest effects being obtained for group setting exercise interventions, with delivery by a health/medical professional, and in a diseased rather than healthy population [20]. In addition, the majority of studies used a cross-sectional or longitudinal design, which does not allow determination of causality and limits the rigour of the research evidence

105 [18]. Others assess loneliness as a secondary outcome within a number of other psychosocial
106 outcomes, which limits the ability to fully examine the effectiveness of these interventions for
107 reducing loneliness [23].

108

109 Further, a number of moderating, such as global [23, 24] and domain-specific self-efficacy [25] and
110 mediating (driving the influence of PA on loneliness) factors, such as social support [26] between
111 loneliness and PA may help to determine additional pathways of any PA intervention effects.

112 Bearing in mind the limitations of the current literature, understanding the mechanisms through which
113 PA may reduce loneliness may bring new insights to the design of novel and effective PA
114 interventions [18]. Further research is needed to explore the association between loneliness, self-
115 efficacy and social support in the context of PA interventions for older adults. However, before the
116 mechanisms can be fully understood, the practicalities and feasibility of implementation of such
117 interventions with older adults should be tested in a feasibility trial [27] before proceeding to a
118 definitive RCT. In order to assess participant experiences of such interventions, the present study
119 utilised a mixed-methods research design, defined as the class of research where the researcher mixes
120 or combines quantitative and qualitative research techniques, methods, approaches, concepts or
121 language into a single study [28]. This research design can add valuable knowledge into a feasibility
122 study. The aim of the study was to examine the feasibility of the Physical Activity Intervention for
123 Loneliness (PAIL) intervention in community-dwelling older adults at risk for loneliness. For the
124 planned future large-scale RCT, the primary hypothesis was that, compared with the inactive control
125 group, participants in the intervention group would report a greater decrease in loneliness. The
126 secondary hypothesis was that participants in the intervention group would significantly increase their
127 amount of physical activity engagement per week, and this would be associated with greater positive
128 changes in other psychosocial and health outcomes compared with the control group participants. The
129 following specific aims of this feasibility study were to estimate:

1. Recruitment rate, attendance and retention rates (number of participants completing the study as a proportion of those randomised).
2. The acceptability of the intervention by participants, and willingness to participate.
3. The appropriateness of the statistical methods of data analysis used.
4. The required sample size for a future large-scale RCT derived from a power calculation.
5. The acceptability of measures, and the most suitable primary outcome measure for a future large-scale RCT.

In addition, to reflect the aims of a future large-scale RCT that this feasibility study was seeking to inform, the effect sizes between the intervention and control groups were examined, however the analysis was exploratory due to feasibility studies not being adequately powered to test the effectiveness of the intervention [29].

Methods/design

The full description of methods is available elsewhere [30]. A brief description is presented here. PAIL was a two-arm, 12-week randomised feasibility trial with a wait-listed control group delivered in Birmingham, United Kingdom, from February 2018 to August 2018 and ran in two waves of data collection. The trial was approved by the Science, Technology, Engineering and Mathematics (STEM) Research Ethics Committee of the University of Birmingham, UK (ERN_16-1419A). This feasibility study was guided by a populated CONSORT Extension to Pilot and Feasibility Trials (Additional file 1) and template for intervention description and replication (TIDieR) checklist [31] (Additional file 2). Written informed consent was obtained from all participants prior to entry into the study.

Participants

Recruitment

Participants were recruited in two waves from September 2017 to April 2018 from the local neighbourhood (households) and communities in Birmingham via leaflets. Additional recruitment was facilitated during the eligibility screening [32]. Recruitment was aimed to be at a rate of 10 participants a month (to a minimum of 40 participants) for estimation of the critical parameters of the feasibility study [33].

Initial eligibility was the phone-based with the further eligibility screening conducted at the university centre. After providing informed consent, participants were invited to a presentation meeting about the study. This was delivered at the University by the main researcher (AS), and included a detailed description of the project aims, methods and procedures, and a Question and Answer session. Attendees were invited for further eligibility screening at the university. Potentially eligible participants identified after baseline screening were randomised into the intervention or a WL control group using a computer-generated random sequence performed by an external researcher not involved in the delivery of the intervention or outcome assessment. Participants were informed about the group allocation by e-mail or a phone call by a person not involved in assessments or delivery of the intervention. At the outcome assessment level, participants who were assessors of their own psychosocial outcomes using questionnaires, were blinded to their group allocation at the time of completing the initial questionnaires. Intervention providers who were responsible for outcome assessments were not blinded to the intervention delivery as this would not be possible, given that the PhD student researcher (AS) conducted the study and walks.

Eligibility

Participants were eligible if they were: 1) community-dwelling older adults aged 60 years and older; 2) previously sedentary (i.e. less than 20 minutes of moderate-to-vigorous PA (MVPA) per week over the past month) [34]; 3) at risk of loneliness and having ≥ 6 out of 9 points on the 3-item loneliness scale during the phone screening [35]; 4) physically mobile as measured using the Short Physical

Performance Battery (SPPB) [36] with a score ≥ 9 out of 12 [37]; 5) having chronic diseases but ambulatory; 6) able to give written informed consent; and 7) English speaking and able to complete paper and pencil questionnaires. Exclusion criteria were: <60 years old, regularly physically active or already engaged in another PA intervention, socially active, having a disease that seriously precluded participation in PA, having a cognitive impairment as assessed by the Montreal Cognitive Assessment (MOCA) [38] with a score ≥ 22 out of 30 [39] and not English literate.

Intervention development and delivery

The development of the PAIL intervention was a results of collaborative work of research group based on the characteristics of effective interventions obtained our previously published systematic review [20]. The theory of active engagement [40] influenced the choice of moderators such as social support and a self-esteem through acquired sense of purpose and confidence during enjoyable forms of PA. The walking group leader attended a training course focused on exercise for older adults “Move it or lose it” [41] and was a certified group exercise instructor. The intervention was a group walking intervention with an education workshop on healthy ageing topics alongside each walking session once per week. After the pilot of the entire intervention with five people and feedback obtained at focus group interview conducted in March 2018, minor changes were needed to modify the delivery approach of the intervention. Firstly, it was suggested to facilitate the recruitment of participants by contacting the 1000 Elders group [42] and the BVSC consortium [43] to advertise the intervention for the summer period. Due to a small number of participants per group, the intervention was lacking the necessary social interactions between participants. Therefore, it was suggested to add new participants who were eligible to join the current groups, and identify the start date of their 12-week intervention from the day they joined (e.g. on a rolling basis). Participants received a weekly e-mail with information about the walking route and a topic of the workshops to set appropriate expectations and help them prepare for the discussion. Weekly information about social events was added to support local engagement with activities and facilitate within group social support.

208 Additionally, free access was gained to Winterbourne House and Gardens (add in website link to
209 Winterbourne here) to deliver a healthy workshop, which included free beverages”.

210

211 **Interventions**

212 The PAIL feasibility study was a 12-week intervention consisting of group walks and health
213 educational/social interaction workshops performed once weekly for a duration of up to 90 minutes
214 per session. The design and features of the PAIL intervention were derived from the findings from a
215 systematic review of PA interventions for loneliness by Shvedko et al. [20]. The theory of active
216 engagement [40] influenced the choice of moderators such as social support and a self-esteem through
217 acquired sense of purpose and a confidence during enjoyable forms of PA. The PAIL was a face-to-
218 face intervention delivered in small groups (up to 8-9 people per group) by a trained walk leader
219 certified in group exercise to older adults and run in various locations and parks in Birmingham, UK.
220 Prior to the first walking session, participants received a copy of a General Practitioner (GP) letter to
221 inform their doctor of participation. Walking sessions were based on the principles of gradual
222 progression and adaptation to PA [44]. The intensity of the walks was light-to-moderate and was
223 monitored objectively by heart rate monitors using the age-predicted heart rate maximum (HR_{max})
224 method [45] and subjectively using the talk test [46] and the 0-10 Borg Ratings of Perceived Exertion
225 scale (RPE) [47]. Participants had to talk back comfortably during exercises using the talk test [46],
226 and rate their RPE from 2 to 4 [47]. Participants followed a trained walking leader via a specific route
227 (Additional file 3). A warm-up preceded each session followed by an end of session cool-down and
228 breathing exercises. Group walking sessions were followed by health education/social interactions
229 workshops on a variety of healthy ageing topics such as eye hygiene, mental health and well-being,
230 preventing falls, social support, nutritional guidelines, and PA recommendations for older adults
231 where participants shared their knowledge and experiences about the topics discussed.

232

233 ***Intervention group***

234 After randomisation, participants in the intervention group started the 12-week intervention.

235

236 ***Wait-listed Control group***

237 Participants in the WL control (delayed intervention) group started the intervention after their follow-
238 up measures were completed, approximately 12 weeks post-randomisation.

239

240 **Measures**

241 All measures were conducted at the host academic institution at baseline and immediately post the
242 intervention period. Participants provided socio-demographic information about their age, gender,
243 ethnicity, marital status, living arrangements, level of education, any children, employment status and
244 any medical conditions. *Cognitive function* was assessed using a Montreal Cognitive Assessment
245 scale (MOCA) designed to test mild cognitive impairment [38]. *Physical functioning* was assessed
246 using the Short Physical Performance Battery (SPPB) [36]. *Height* was measured to the nearest 0.1
247 cm using a stadiometer (Seca AG, Reinach, Switzerland) and recorded in metres. *Weight* was
248 assessed using weighing scales (Tanita UK Ltd., Middlesex, UK) to the nearest 0.1 kg. *Resting blood*
249 *pressure* (BP rest, mm Hg) was measured using a portable semi-automatic OMRON
250 sphygmomanometer (OMRON HEM705CP sphygmomanometer; Omron Matsusaka Co Ltd, Japan).
251 *Physical activity* was measured using ActivPAL accelerometers (PAL Technologies Ltd, Glasgow,
252 UK) at baseline and immediately post intervention over a continuous 7-day period of awake and
253 sleeping (24 hours a day) except when bathing or swimming [48].

254

255 ***Questionnaires***

256 *Loneliness* was assessed using the 8-item UCLA Loneliness Scale (UCLA-8) [49]. *Social support*
257 was assessed using the 20-item Medical Outcomes Study Social Support Survey (MOSSSS) [50].
258 *Social networks* were categorised using the 6-item Lubben's Social Network Scale (LSNS-6) [51].
259 *Depression and anxiety* were assessed using the 14-item Hospital Anxiety and Depression Scale

260 (HADS) [52]. *Self-efficacy for exercise* was measured using the revised 9-item Self-Efficacy for
 261 Walking/Exercise Scale (SEE), using a paper-and-pencil format [53]. *Satisfaction with level of social*
 262 *contacts* (SSC) was measured with the question “How satisfied are you with your social contacts?”
 263 [54]. *Expected outcomes and barriers for exercise* were measured using the Expected Outcomes and
 264 Barriers for Habitual Exercise scale [55] adapted for the older adult population. Four questions related
 265 to sport competence were deleted from the expected outcomes sub-scale due to irrelevance for this
 266 population group [55]. The expected outcomes and barriers for exercise scale has demonstrated good
 267 internal consistency from 0.66 to 0.85, and a high test-retest reliability of 0.78 in previous research
 268 [55].

269

270 ***Qualitative assessments***

271 To understand participants’ experiences of taking part in the PAIL feasibility trial, focus groups were
 272 conducted at mid-point (between week 4 and 5) and at the end of the 12-week intervention using
 273 semi-structured discussions in groups of 4-9 people per group of mixed gender (Additional files 4,5)
 274 on the following topics: reasons for participation, progress on intervention delivery and possible
 275 barriers to attending. The research team iteratively analysed the mid-point data to identify if any
 276 alterations in the intervention were required based on the participants’ feedback. Focus groups were
 277 audio recorded using a digital recorder and transcribed verbatim. An independent trained focus group
 278 leader acted as moderator and facilitator of the focus groups [56].

279

280 ***Feasibility outcomes***

281 The following specific aims of this feasibility study were assessed:

- 282 1) Attendance was calculated as the total number of attended sessions divided by the total number of
- 283 sessions of the intervention and recorded as a percentage;
- 284 2) Recruitment rate was calculated as the number of individuals responding to advertisements and
- 285 friends' referrals out of a total number of formal invitations given/advertisements placed (including

286 web-based advertisements, advertisements placed in the local cohort groups and poster and leaflet
287 material disseminated in the community). Recruitment rate was recorded as a percentage, e.g. 25%
288 (48/195). It is acknowledged that advertisements may reach a large number of individuals, but it
289 was impossible to quantify this;

290 3) Retention rate was calculated as number of participants completing the study as a proportion of
291 those randomised;

292 4) The assessment rate of questionnaires was evaluated as the total number of completed
293 questionnaires divided by the total number of questionnaires and recorded as a percentage;

294 5) The suitability of the statistical methods of data analysis was investigated using reliability analyses.
295 Internal consistency reliability (Cohen's alpha) was calculated at each time point (pre and post) and
296 averaged to give overall reliability. The expected outcomes and barriers for exercise questionnaire
297 was completed twice at baseline, with a week between measures, to allow for test-retest reliability
298 analysis.

299 6) The acceptability of the intervention by participants, and willingness to participate was assessed
300 using focus group interviews. The focus group transcripts were analysed using a phenomenological
301 inductive approach [57], and these data were used to guide the research team in improving the quality
302 of the delivered intervention by informing positive changes in the methodology and design of the
303 intervention for the future implementation in a consequent study;

304 7) Statistical power and sample size estimation was calculated for meaningful potential future primary
305 outcomes (e.g. loneliness or social support) using a method based on the differences in means between
306 the intervention and control groups, using G-power software [58];

307 8) An effect size (ES) was calculated for loneliness, social support, social networks, anxiety and
308 depression, self-efficacy for exercise, satisfaction with level of social contacts, and the expected
309 outcomes and barriers for exercise. Means (M) and standard deviations (SD) were used to investigate
310 the effect size for change in loneliness using mixed between (intervention group vs. control group)

311 and within (over time) repeated-measures analysis of variance (ANOVAs) with post-hoc
312 comparisons.

313

314 **Data monitoring**

315 The data monitoring committee for this project was the supervisory research team (three academic
316 supervisors). They were responsible for checking accuracy of quantitative data upon assembly of the
317 final database following completion of data collection prior to data analysis. The qualitative data were
318 analysed iteratively by AS with independent analysis and oversight by a member of the supervisory
319 team with expertise in qualitative and mixed methods research (JT). AS was responsible for
320 monitoring and reporting spontaneous adverse events or any unintended trial effects to the
321 supervisory team, and the primary supervisor (AW). The trial was also subject to independent audit
322 request by the sponsor, the University of Birmingham, by a team independent of the
323 supervisory/research team.

324

325 **Data collection**

326 Data were collected at the university facility at screening, baseline and post-intervention period (12
327 weeks after the start of the intervention). After providing baseline eligibility screening, potential
328 participants were offered a total of five visits for health assessments at the university facility.
329 Participants in the intervention group had an additional sixth visit for attending the mid-point focus
330 group.

331

332 **Sample size**

333 As this was a feasibility study to inform the design of the future large-scale RCT, a total targeted
334 sample of 40 older adult participants was considered necessary to be recruited for estimation of the
335 critical parameters [33] with 20 in the intervention group and 20 in the WL control group.

336

337 **Progression criteria**

338 The progression criteria to a definitive large-scale RCT were: 1) no any serious adverse events, such
339 as hospitalisation, life-threatening condition, death and any adverse events associated with the
340 intervention experienced by less than 5% of participants per group; 2) recruitment rate of no less than
341 75% by the end of the four months recruitment period; and 3) retention rate of no less than 75% in
342 each group at 12 weeks (end-point). If all three criteria were not met, there would be insufficient
343 evidence to justify proceeding to the definitive RCT. No targets were set for other feasibility
344 outcomes, e.g., questionnaire completion rates or attendance at the intervention sessions.

346 **Data analysis**

347 Quantitative data were analysed using SPSS version 22.0 for Windows (SPSS Inc., Chicago, IL)
348 employing an intention-to-treat analysis (based on their treatment allocation and irrespective of
349 participants' adherence or withdrawal) [59]. The level of significance was set at $p < .05$, however any
350 hypothesis testing was preliminary, and any results were interpreted with caution as this feasibility
351 study is underpowered and the analyses based on small numbers. Baseline differences between groups
352 for continuous data (e.g. age, BMI, resting blood pressure, number of comorbidities, cognitive and
353 physical functioning, and outcomes of questionnaires) were analysed using one-way analysis of
354 variance (ANOVA). Chi-squared tests were applied for nominal data (e.g. gender, ethnicity, marital
355 status, living arrangements, level of education, children, and employment status). For descriptive
356 statistics, data were presented as means (M) and standard deviations (SD). Nominal data were
357 presented as number (N) and percentage. Mixed between (group) and within (time) repeated-
358 measures ANOVAs with post-hoc comparisons were applied to investigate the effect of the
359 intervention versus control on psychosocial outcomes (loneliness, social support, support networks,
360 depression, anxiety, self-efficacy for exercise, satisfaction with level of social contacts), expected
361 outcomes and barriers for exercise, and accelerometer data. The accelerometer data were analysed
362 using the ActivPAL software V7.1.18 (PAL technologies, Scotland, UK). Recorded data were

downloaded to a computer, and data for average daily amount of stepping (step counts), average time lying and sitting (h) in increments of 15 s, average time standing (h), and energy expenditure (EE, MET/h) were analysed using mixed between (intervention group) and within (time) ANOVAs. For the Expected Outcomes and Barriers for Habitual Exercise scale [55], additional test-retest reliability was calculated via correlation. In order to explore which outcome measures are likely to be most important for the main trial, Pearson's correlations were performed between calculated change scores over time in the experimental group for all psychosocial outcomes (Lubben's social networks, loneliness and self-efficacy for exercise) and change scores for averaged daily physical activity (time lying/sitting (h), time standing (h), time stepping (h), step counts, sit to stand transitions (n) and energy equivalent (METs/h)). Statistical power and sample size estimation for a future large-scale RCT were calculated for meaningful outcomes (e.g. loneliness or social support) using the method based on the differences in means between the intervention and control group using the G-power software Version 3.1 [58].

Qualitative study

Qualitative data were thematically analysed by two research team members independently using a phenomenological inductive approach [57]. Transcripts were returned to participants for comments/correction to ensure transparency and trustworthiness of the data (member checking) [60]. Validated transcripts were read several times by the two independent researchers to obtain an overall meaning. Then, themes and subthemes with important meanings common across all participants were derived from the obtained data. Results were compared through discussion between reviewers [61]. Data were pseudo-anonymised with a unique identification number (ID) and stored confidentially in locked filing cabinets/on password protected university computers accessible only to the research team. Audio recordings were destroyed after the recordings were transcribed verbatim.

Results

389 **Participant characteristics**

390 Participants were 25 (mean (SD) 68.5(8.05) years, range 60-92 years) healthy, inactive, community-
391 dwelling older adults, 14 (56%) female, and 18 (72%) white. Baseline descriptive statistics of
392 participants are shown in Table 1.

393

394 **Feasibility and safety**

395 ***Recruitment and retention***

396 The flow of participants through the study is shown in Figure 1. The intervention was advertised
397 using 192 advertisements (145 leaflets and 47 advertisement posters), which yielded a total of 48
398 potential participants (45 expressing the initial interest and three recruited through friends'
399 referrals). The recruitment rate was 25% (48/195). Two declined to participate before completing
400 the phone-based screening. Forty-six potential participants were assessed for
401 eligibility using the phone-based screening with 21 excluded due to not meeting the eligibility

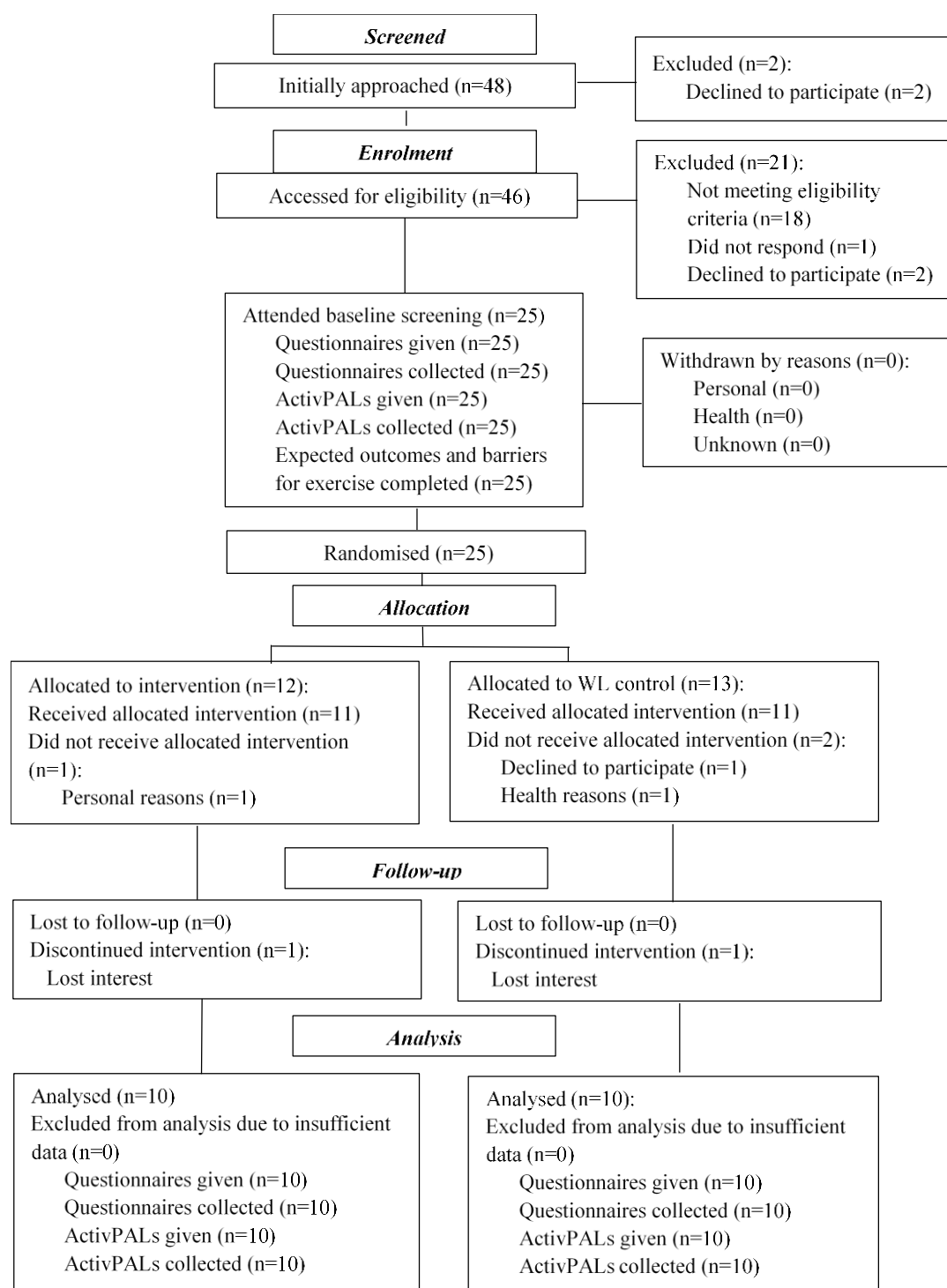


Fig. 1. CONSORT flow diagram of Physical Activity Intervention for Loneliness (PAIL) intervention.

criteria (N=18), declined to participate (N=4) and no response (N=1). Reasons for not being eligible were already physically active or taking part in another intervention (N=11), or not at risk of loneliness (as assessed using the phone-screening tool) (N=7). Reasons for declining to participate were pressures of work/lack of time and health reasons. A total of 31 participants (31/46, 67.4%)

410 attended the further eligibility screening at Visit 1, and 25 were eligible to proceed with baseline
 411 assessment (Visit 2). Using Wilson's 95% confidence interval [62], at 12 weeks, 10/12 (83.3%;
 412 95% CI 55.20 to 95.30) intervention and 10/13 (76.9%; 95% CI 49.74 to 91.82) control participants
 413 completed final assessments. The retention rate satisfied the criteria of the study, e.g. > 75% of
 414 participants at 12 weeks (end-point period), although the recruitment rate of 25% by the end of the
 415 four months was somewhat lower than was initially proposed at 75%. There were no serious
 416 adverse events, or any adverse events observed related to study participation.

417

418 ***Attendance***

419 The average attendance rate for the total of 12 sessions of the walking intervention was 58.3% for the
 420 intervention group, with attendance ranging from 33.0% to 75.0% (Additional file 6). The average
 421 attendance rate for the WL control group was 42.3%, with attendance ranging from 23.1% to 69.2 %.
 422 The mean (SD) number of attended sessions per person was 8.6(2.8) and 6.6(2.6) in the intervention
 423 and wait-list control group, respectively. After completing the 12-week intervention, 7/10 participants
 424 from the intervention group and 6/10 participants from the wait-list control group continued walking.
 425 The follow-up attendance rate assessed during the 12-week post-intervention period was 48% for the
 426 intervention and 52% for the WL control group.

427

428 ***The assessment rate of questionnaires***

429 Baseline questionnaires and accelerometer data were provided by 100% (25/25) of participants
 430 recruited into the study. Post-intervention questionnaires and end-point accelerometer data were
 431 provided by 100% (10/10) of the intervention and 100% (10/10) WL control group participants.

432

433 ***The appropriateness of the assessment tools***

434 The average reliability was high for all psychosocial outcomes: loneliness (Cronbach's alpha 0.857),
 435 social support (Cronbach's alpha 0.975), Lubben's social networks (Cronbach's alpha 0.721),

depression (Cronbach's alpha 0.744), anxiety (Cronbach's alpha 0.693) and self-efficacy for exercise (Cronbach's alpha 0.925). The expected outcomes for the exercise sub-scale of the Expected Outcomes and Barriers for Exercise questionnaire showed high internal consistency reliability at baseline, with Cronbach's alpha equalling 0.926 (a week before) and 0.938 (a week after); at post-intervention the value was 0.976. Barriers for the exercise sub-scale of the Expected Outcomes and Barriers for Exercise questionnaire showed high internal consistency reliability at baseline, with Cronbach's alpha equalling 0.888 (a week before) and 0.924 (a week after); at the post-intervention period the value was 0.943.

Findings from the qualitative study

The appropriateness, practicality and acceptability of the intervention by participants

A total of 5/12 (42%) participants in the intervention group attended two focus group interviews, at the mid-point and end-point intervention periods. The focus group attendees were representative of the overall intervention group characteristics. The responses of participants during the focus groups were summarised in the main themes for mid-point and end-point intervention periods and presented below.

1. Mid-point focus groups

Participants ranged in age from 62-76 years, 60% (3/5) female, 80% white, with 60% (3/5) living alone, having a university degree, having children, being retired and having one medical condition. The main themes were: study design and recruitment (3 subthemes), healthy workshops (3 subthemes) and walking sessions (3 subthemes) (Additional file 4).

Mid-point focus group results showed that in terms of the appropriateness and practicality, the spring-summer seasons were a better to start the intervention than winter time. Overall, participants had very

461 positive views of the walking intervention, particularly the benefits of walking, its cost-effectiveness
 462 in terms of the economic benefits for older adults and direct positive health effects:

463 *“And because I am on a fixed income now, you know I can’t just go out and earn a bit more money*
 464 *to do something, it does limit you a little bit in what you can do and you have got all this time, but*
 465 *you haven’t got the money. Err, you know, and I brought up a child on my own so she took quite a lot*
 466 *of my salary when I was working [Kate laughs], you know I have never got a lot of money (all laugh)*
 467 *to do what I would really like to do. So, you have to work within that (.)”* (Alison, 75, female).

468

469 For others, it was a chance to meet new people and get access to local community groups:

470 *“I mean walking is good because it loosens everybody up a bit, gets people to know each other (.)”*
 471 *(Andrew, 68, male).*

472

473 The content of the healthy workshops was relevant and allowed them to share feelings and
 474 knowledge. However, the main barriers to attend walks were: 1) personal, such as lack of time
 475 associated with family and community celebrations, holiday, home refurbishments, and carer
 476 responsibilities; and 2) environmental barriers, such as transportation and the weather (Additional file
 477 3). Participants found it difficult to get to the location by public transport, or to find the nearest parking
 478 area if the meeting point was on campus:

479

480 *“And some of the walks, like [the place of the walk], although it wasn’t that particularly early, it’s*
 481 *getting there (.) [an issue] on public transport”* (Sarah, 76, female).

482

483 **2. End-point focus groups**

484 Participants ranged in age from 65-76 years, 20% (1/5) female, 80% white, 60% (3/5) living alone,
 485 40% (2/5) with university degree, 60% having children, retired and having one or more medical
 486 condition. The main themes were: study design and recruitment (3 subthemes), healthy workshops

487 (3 subthemes), and walking sessions (2 subthemes) (Additional file 5). Participants felt that
 488 participation in the intervention helped them to become more physically active, which was their
 489 initial aim:

490 *“You have to just try and keep motivating [yourself], just keep going I suppose, rather than just*
 491 *sitting at home. I don’t know how (.) for me like, I am working four days a week at the moment, so I*
 492 *don’t know how I would feel when I retire, which is going to happen next year so (.)”* (Ben, male,
 493 65).

494
 495 *“I enjoyed the exercise thing. It is quite, you know (.) it is just (.) She (referring to the exercise leader)*
 496 *sort of said, you know, made us aware of sort, of what sort of exercise is good for, what parts of your*
 497 *body and so forth. So, I mean it is important, isn’t it to keep moving, keep active and this is what part*
 498 *of the programme is about, isn’t it?”* (Ben, male, 65).

499
 500 Common interests raised during the walks allowed first friendship gains that started from as early as
 501 the second or third walk and continued after the programme’s end at 12 weeks. Walking was seen to
 502 promote the bonding of participants and improved their aspirations for friendship-based relationships:
 503 *“I have definitely made new friends, enjoyed meeting new people and you gel with some people*
 504 *which is a human nature, so (.)”* (Sarah, female, 76).

505
 506 Future recommendations included more group leaders per group and classification of walks by ability
 507 level (e.g. beginner, improver):
 508 *“(.) and it was only (the Researcher). But if (the Researcher) had two other people on our walk (.).*
 509 *You can do a slow one slightly less (distance), a medium one slightly further and a faster one even*
 510 *further. I don’t know how you would organise that, but that would take care of the pacing (.) The*
 511 *Researcher will need help. You can’t do that with one person because you got to lead, so she actually*
 512 *does need somebody to lead a group”* (Alison, 75, female).

513

514 Another suggestion was to conduct healthy workshops during a separate session/time:

515 “-You suggest a separate session for loneliness? (Focus group lead).

516 -A separate [Kate: a separate session yeah (.)] without so many leaflets (Alison, 75, female).

517 -Yeah, so that will be a little bit (.) it will be a good focus for each of us to learn, to share (.)” (Kate,
518 62, female).

519

520 **Changes in outcome measures**

521 There were no significant differences between the intervention and control groups at baseline in all
522 measures except for number (n) of sit-to-stand transitions, which were 14.4 points lower in the
523 intervention group (mean 43.3(11.3)) compared with controls (mean 57.6(15.8); 95% CI 2.91, 25.81).

524 Table 2 shows the between group differences for secondary outcomes. In general, a pattern of
525 improvement was seen across all psychosocial and physical activity outcomes in the intervention
526 group. All correlations performed for psychosocial outcomes are shown in Table 3. Correlation
527 analysis performed for calculated change scores over time in the experimental group for all
528 psychosocial outcomes showed no significant correlations between any other psychosocial outcomes
529 except for a moderate negative correlation between self-efficacy for exercise and loneliness, and a
530 moderate negative correlation between self-efficacy for exercise and the family sub-scale of Lubben’s
531 social networks. A moderate positive correlation emerged between self-efficacy for exercise and the
532 friendship sub-scale of Lubben’s social networks, such that an increase in self-efficacy for exercise
533 was associated with a larger family and friends social network size.

534

535 **Power Calculation**

536 The potential sample size for a future large-scale trial was calculated for each psychosocial outcome
537 using *post-hoc* analyses first to estimate the observed power based on the effect sizes from the
538 repeated measures between-within ANOVAs on the 25 participants using the partial eta-squared from

the interaction effect (η^2). Following this, a sample size was calculated *a priori* for a future trial using $\alpha = 0.05$ and power at 80% for each measure: loneliness (N=72, $\eta^2=0.014$), social support (N=48, $\eta^2=0.030$), Lubben's social network (N=48, $\eta^2=0.026$), depression (N=378, $\eta^2=0.008$), anxiety (N=68, $\eta^2=0.032$), SEE (N=12, $\eta^2=0.122$), expected outcomes (N=60, $\eta^2=0.033$), and barriers for exercise (N=172, $\eta^2=0.011$) (Additional file 7). The calculation of estimated sample size for SSC was not possible as $\eta^2=0.000$ (insufficient power).

Discussion

This study assessed the feasibility of the Physical Activity Intervention for Loneliness (PAIL) intervention in community-dwelling older adults at risk for loneliness. Based on the progression criteria, the retention rate was satisfactory, e.g. >75% of participants at 12 weeks (end-point period), as well as no adverse events during the intervention. The recruitment rate of 25% by the end of the four months was somewhat lower than initially proposed at 75%. Therefore, only two out of three criteria of progression to the definitive RCT were satisfied, meaning that the study was not feasible to deliver in its present form. However, these findings were not surprising based on the inability to accurately estimate recruitment rates in the present study, as well as the fact that it is difficult to access socially isolated older adults who may be less interested in joining an intervention than those who are more socially engaged. Therefore, recruitment from GPs may be more advantageous than advertisement via mass media resources such as leaflets or advertisement posters in a future large-scale trial to recruit older adults at high risk of loneliness or social isolation [20, 63, 64].

The low attendance rate (58.3% for the intervention group, 42.3% in the WL control group) in this study is not surprising given that the PA intervention is considered to be a behaviour change strategy that is not easily initiated or consistently maintained in older adult populations [65]. Based on participant responses, providing transport to and from walking session locations may significantly improve adherence and provide easier access to various locations of walks to maintain interest of older adults.

565 No significant changes in outcome measures were found after 12 weeks of the PAIL intervention. As
566 reported in the literature, the acute exercise effect is brief [66] and a longer duration intervention as
567 well as an adequate follow-up period of the future intervention may be needed to allow participants
568 to build upon transforming new contacts into meaningful relationships based on trust, which previous
569 studies suggest may be up to 5 months [67, 68].

570 Given that the initial aim of the intervention was to see if loneliness could be impacted, and the
571 observed power and estimated sample size for this seems achievable, this could be recommended as
572 a future primary outcome. However, a feasibility study, by its very nature, may be under powered to
573 achieve statistical significance at $\alpha=0.05$ [69]. Therefore, any interpretation based on significance
574 levels should be treated with caution. Post-hoc sample size calculations were possible, however are
575 not advisable for feasibility studies [70]. Therefore, additional feasibility is recommended using the
576 minimum clinically important difference (MCID) [69], which was performed for depression and
577 anxiety as they had a set cut-off point of 4 scores. The mean between group difference at 12 weeks
578 was non-significant and less than the a priori determined MCID of 4 points with 95% CI crossing
579 zero (MD=1.0, 95% CI: -1.8 to 3.9, $p=0.457$), suggesting that the results are equivocal. Similar results
580 were obtained for anxiety (MD=-0.5, 95% CI: -3.4 to 2.5, $p=0.744$). Given the small effect sizes for
581 SCC, a sample size calculation was not possible, thus future feasibility testing of this measure is
582 advised. The efficacy outcomes of the current feasibility study may be used in exploratory analyses,
583 but further changes in the intervention design and methods are required before proceeding to a
584 definitive trial. For example, a larger sample and more rigorous recruitment strategy, as well as easier
585 access to walking locations may significantly improve the quality of future research. A future
586 intervention would also be advised to: 1) classify walking groups by ability level; 2) add more group
587 leaders per group; 3) conduct healthy workshops during a separate session/time; 4) provide transport
588 to walking locations in order to maintain high adherence and diversity of routes; and 5) conduct focus
589 group discussions for control participants to understand their experience of the research processes,
590 questionnaires and other elements.

591

592 **Strengths and limitations**

593 This study had a robust design and highlighted the importance of PA interventions for loneliness in
594 older adults based on the lack of existing research [20]. Walking was chosen as it has been shown to
595 be the most feasible and cost-effective method of physical activity for older adults [71, 72]. Other
596 strengths of this study include objective measurement of PA, use of reliable methods of assessment
597 of psychosocial outcomes in older adults, and the mixed methods research design that allowed for
598 collecting feedback from participants during and at the end of the intervention.

599 Study limitations include selection bias associated with the recruitment of physically mobile
600 participants as assessed during the eligibility screening. Therefore, any treatment effect of this
601 feasibility study may be blunted by this selection bias [14, 21] and inclusion of higher functioning
602 older adults. The identification of sedentary individuals in this study was done using the modified
603 short form of the CHAMPS physical activity questionnaire adopted for use in an older adult
604 population [73]. For future studies it is advisable that instead of using this general normative
605 definition of a sedentary individual, this exclusion criterion could be exclusive to walking. Future
606 studies should consider using objective methods of assessment of PA (e.g., pedometers or
607 accelerometers) in older adults in addition to the phone-based screening for a rigorous eligibility
608 process. The optimum dose was not a feasibility outcome in the present study. However, the low
609 attendance suggested that more frequent sessions would not be feasible. In terms of PA, the ideal dose
610 would be a total of 150min per week, but the present study suggests this is unlikely. Appropriate
611 blinding of the researcher was not possible in the present study due to a lack of resources available to
612 pay an independent person to deliver the intervention and collect all of the data. As such, it is
613 recommended that future studies are resourced to allow for the recruitment of a trained walking leader
614 to deliver the intervention and an independent assessor of outcomes to allow for adequate blinding
615 and reduce detection bias. The mixed design of the intervention allowed for the enrichment of the
616 quantitative data of the intervention by including the opinion of participants about the study.

However, the low attendance of focus groups was a limitation. Out of 12 people in the intervention group, only 58.3% attended the 12-week intervention with a mean (SD) number of attended sessions per person 8.6(2.8). The reasons for not attending focus groups were work/lack of time, health reasons and other (e.g. transport difficulties, lack of motivation, family reasons). In addition, older adults with loneliness may have barriers for open discussions due to the “stigmatising nature of loneliness,” [14, 74-76]. Therefore, a future study may consider using one-to-one interviews instead. In addition, WL control group participants may have experienced a significant placebo effect (a worsening symptom or disappointment) [77]. Compared to control group designs with no treatment, participants with WL control group designs have a hope for the intervention delivered later, however, this may also induce frustration [78]. This may be especially true for lonely older adults with high levels of depression or anxiety, and the likelihood of worsening their psychological well-being is high which, in turn, may influence questionnaire responses. Future research should attempt to address these issues by changing the control group design to a no treatment control, but this brings its own ethical issues surrounding not offering an intervention to individuals who have the potential to benefit from it. It should be acknowledged that even with the use of the loneliness screening measure, individuals with highest loneliness risk may be those least likely to respond to an invitation to eligibility screening due to low confidence and motivation.

Conclusions

The present study suggests that community-dwelling older adults at risk for loneliness can successfully complete a 12-week walking intervention programme, reporting enjoyment and benefits, and they were keen to share their knowledge and experiences during the healthy/social workshops. The efficacy outcomes of the current feasibility study may be used in exploratory analyses, but the changes suggested above to the intervention design and methods would be necessary before proceeding to a definitive trial. Further feasibility testing based on the different CIs with a MCID set a priori would be advisable.

643

644 **Abbreviations**

645 ANOVA: the repeated-measures analysis of variance; B: the standardised regression coefficient;
 646 BMI: Body Mass Index; BP rest: Resting blood pressure; CHAMPS: Community Healthy Activities
 647 Model Programme for Seniors; CI: Confidence Intervals; EE: energy expenditure; ES: the effect size;
 648 GP: General Practitioner; HADS: Hospital Anxiety and Depression Scale; LSNS-6: 6-item Lubben's
 649 Social Network Scale; M: means; MCID: minimal clinically important difference; MET: the
 650 metabolic equivalent; MOSSSS: the Medical Outcomes Study Social Support Survey; MOCA: the
 651 Montreal Cognitive Assessment; MVPA: Moderate-to-vigorous physical activity; N: number; NHS:
 652 National Health Services; PA: physical activity; PAIL: Physical Activity Intervention for Loneliness;
 653 R: correlation coefficient; RCT: Randomised Controlled Trial; RPE: SD: standard deviations; SEE:
 654 Self-efficacy for exercise scale; SSC: Satisfaction with level of social contacts; SPPB: the Short
 655 Physical Performance Battery; STEM Ethical Review Committee: the Science, Technology,
 656 Engineering and Mathematics Ethical Review Committee; TIDieR: template for intervention
 657 description and replication checklist; UCLA-8: the 8-item The University of California, Los Angeles
 658 Loneliness Scale; UK: The United Kingdom; WL: wait-listed control group.

659

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672

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675

676 **Authors’ contributions**

677 AW, JT and CG advised regarding development of trial design and study protocol, assisted obtaining
678 ethics approval and amendments, helped in facilitating patient recruitment, register study protocol,
679 structure the research stages and oversee all study procedures. JT also helped to design and analyse
680 focus group interviews. FN helped to conduct and analyse focus group interviews. The doctoral
681 research student (AS) obtained funding and was involved in the design of the study protocol,
682 participant recruitment, health assessments and implementation of the intervention.

683

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688

689 **Competing interests**

690 The authors of this review declare that they have no competing interests.

691

692 **Consent for publication**

693 Not applicable.

694

695 **Disclosure statement**

696 The authors of this review declare that they have no known conflicts of interest.

697

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699

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713 [from-the-four-home-countries-chief-medical-officers](https://www.gov.uk/government/publications/start-active-stay-active-a-report-on-physical-activity-from-the-four-home-countries-chief-medical-officers)].
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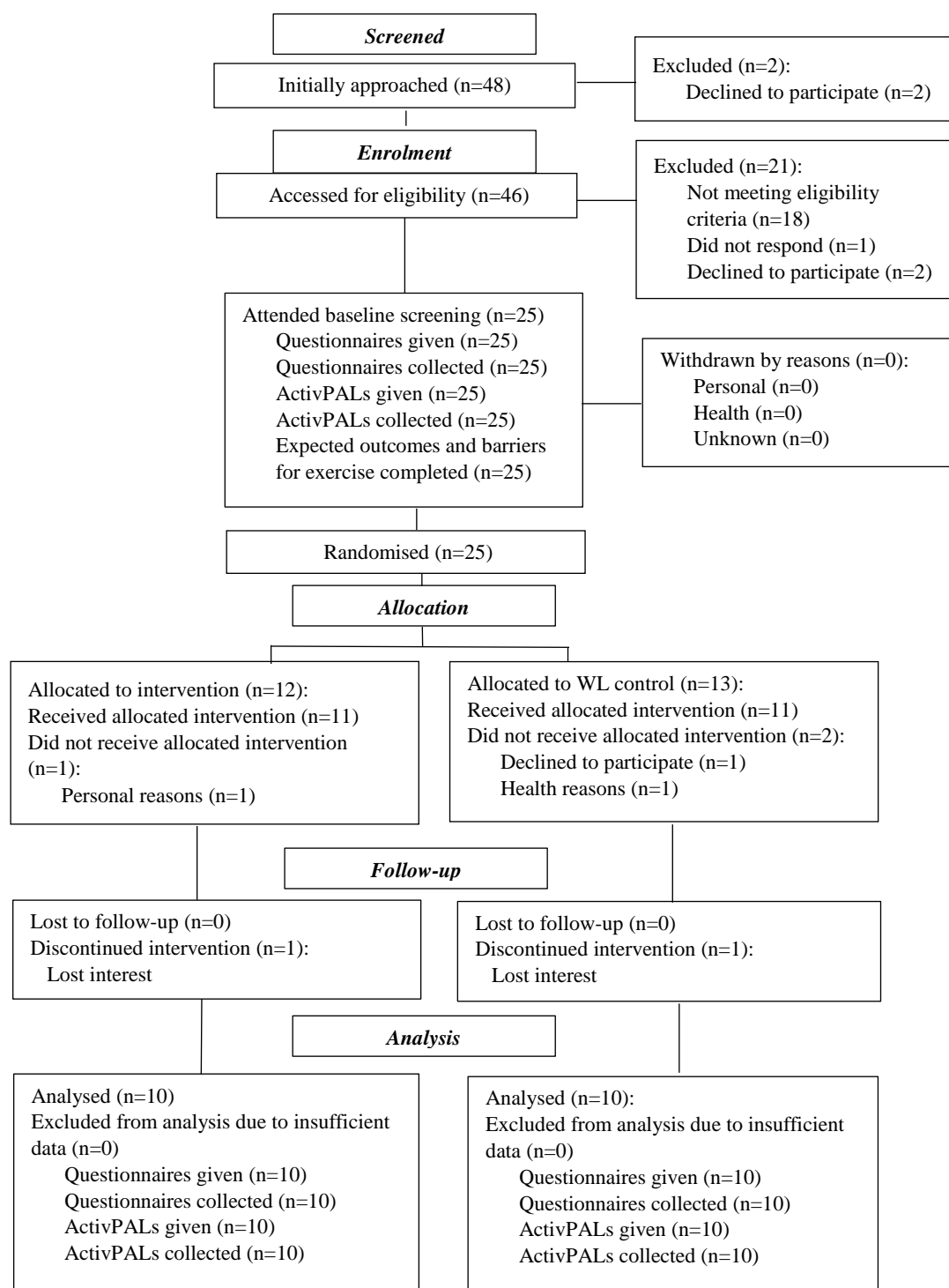


Fig. 1. CONSORT flow diagram of Physical Activity Intervention for Loneliness (PAIL) intervention.

919 Table 1. Baseline socio-demographic, anthropometric and health-related characteristics of study
 920 participants by group (n=25).

Variable	Intervention (n=12)	Control (n=13)
Age, years	68.4(5.9)	67.3(11.5)
Male, n (%)	5(41.7)	6(46.2)
Ethnicity, n (%)		
White	7(58.3)	11(84.6)
Black	2(16.66)	0(0)
Asian	1(8.33)	1(7.69)
Other	2(16.66)	1(7.69)
Marital status, n (%)		
Married	4(33.3)	2(15.4)
Single/never been married	4(33.3)	4(30.8)
Divorced/separated	2(16.7)	5(38.5)
Widowed	2(16.7)	2(15.3)
Living alone, n (%)	8(66.7)	9(69.2)
Education, n (%)		
No qualification	2(16.7)	1(7.7)
Secondary education	2(16.7)	4(30.8)
College degree	3(25)	2(15.4)
University degree or higher	5(41.7)	6(46.2)
Having children, n (%)	7(58.3)	10(76.9)
Not employed /retired, n (%)	10(83.3)	8(61.5)
Comorbidities, n (%)		
0	3(25)	3(23.1)

1	5(41.7)	2(15.4)
≥ 2	4(33.3)	8(61.5)
Physical function (SPPB score ≥ 9 points)	10.3(1.2)	10.8(1.0)
Cognitive function (MOCA score ≥ 22 points)	28.3(1.9)	27.5(2.4)
Height, m	1.7(0.1)	1.7(0.1)
Weight, kg	68.2(12.8)	68.8(14.2)
Body mass index, kg/m ²	24.7(3.0)	24.7(3.4)
Systolic blood pressure, mmHg	128.9(7.9)	133.1(16.6)
Diastolic blood pressure, mmHg	75.7(8.9)	77.9(11.9)

921 Values are the mean (SD) unless indicated otherwise.

922 Abbreviations: n- number; SPPB – Short Physical Performance Battery, MOCA – Montreal

923 Cognitive Assessment scale.

924

925 Table 2. 12-week group differences between intervention and control groups in anthropometric,
 926 health-related, physical activity and psychosocial outcomes from baseline.

Variables	Mean (SD)		
	Intervention (n=12)	Control (n=13)	Difference (95% CI)
Height, m	1.7 (0.1)	1.7 (0.1)	-0.0 (-0.1 to 0.1)
Weight, kg	67.9 (12.6)	68.4 (14.2)	-0.5 (-11.6 to 10.7)
BMI, kg.m ⁻²	24.3 (2.8)	24.5 (3.5)	-0.2 (-2.9 to 2.4)
SBP, mmHg	123.3 (8.3)	129.9 (13.8)	-6.6 (-16.1 to 2.9)
DBP, mmHg	74.1 (8.9)	74.5 (9.6)	-0.4 (-8.1 to 7.3)
Loneliness	18.1 (5.2)	18.6 (5.2)	-0.5 (-4.8 to 3.8)
Social support	63.9 (19.8)	59.8 (20.7)	4.1 (-12.7 to 20.9)
LSN (Total)	15.4 (5.0)	12.0 (6.3)	3.4 (-1.3 to 8.2)
LSN (Family)	6.9 (4.4)	5.9 (3.8)	1.0 (-2.4 to 4.4)
LSN (Friends)	8.5 (2.5)	6.1 (4.9)	2.4 (-0.9 to 5.7)
Depression	6.5 (3.0)	5.5 (3.8)	1.0 (-1.8 to 3.9)
Anxiety	6.9 (3.3)	7.4 (3.7)	-0.5 (-3.4 to 2.5)
SEE	7.1 (1.7)	5.2 (2.2)	1.9 (0.3 to 3.6)
SSC	6.5 (3.1)	5.3 (3.6)	1.2 (-1.7 to 4.1)
Expected outcomes	3.8 (1.1)	3.9 (0.8)	-0.1 (-0.9 to 0.7)
Barriers for exercise	2.6 (0.9)	2.9 (1.0)	-0.3 (-1.0 to 0.5)
Time lying/sitting (h)	16.8 (1.9)	17.1 (1.8)	-0.3 (-1.8 to 1.2)
Time standing (h)	5.5 (1.5)	5.1 (1.6)	0.5 (-0.9 to 1.7)
Time stepping (h)	1.9 (0.7)	1.8 (0.7)	0.1 (-0.6 to 0.7)
Step counts	9067.5 (4355.7)	8575.6 (4117.5)	491.9 (-3013.6 to 3997.5)

Sit to stand transitions (n)	45.3 (10.6)	60.3 (14.6)	-15.0 (-25.7 to -4.4)
Energy Equivalent (METs/h)	34.4 (1.7)	34.1 (1.6)	0.3 (-1.1 to 1.7)

927 Abbreviations: BMI - body mass index, DBP – diastolic blood pressure, n- number, SBP – systolic
928 blood pressure, SEE – self-efficacy for exercise; SSC – satisfaction with social contacts, LSN –
929 Lubben’s social networks.

930 Table 3. Pearson product-moment correlations between change scores of psychosocial outcomes in the Intervention group (n=12).

Scale	1	2	3	4	5	6	7	8	9	10
1. UCLA -8	-									
2. MOSSSS	0.046	-								
3. LSN (Total)	-0.140	0.107	-							
4. LSN (Family)	0.278	0.044	0.593*	-						
5. LSN (Friends)	-0.470	0.057	0.313	-0.579*	-					
6. Depression	0.411	-0.506	0.315	0.126	0.171	-				
7. Anxiety	0.183	-0.503	-0.161	-0.238	0.117	0.530	-			
8. SEE	-0.707*	-0.148	-0.108	-0.648*	0.655*	-0.197	0.131	-		
9. SSC	-0.597	0.381	0.261	0.050	0.216	-0.320	-0.741**	0.425	-	
10. Expected outcomes	-0.043	0.209	0.332	0.223	0.073	-0.106	-0.722**	-0.240	0.563	-
11. Barriers for exercise	-0.229	-0.208	-0.205	-0.437	0.309	0.133	-0.033	0.414	0.422	-0.102

931 Abbreviations: UCLA- 8 – 8-item University of California at Los Angeles loneliness scale; MOSSSS – Medical outcomes study social support survey, LSN

932 –Lubben’s social networks, SEE – Self-efficacy for exercise, SSC – Satisfaction with level of social contacts.

933 Notes: *Significant correlation at $p < 0.05$ (two-tailed), ** Significant correlation at $p < 0.01$ (two-tailed).

